Remarks

Claim Status

Claims 1-22, inclusive, are pending.

Claims 1-10 and 14-22 were rejected as claiming non-patentable subject matter under 35 U.S.C. § 101.

Claims 1-12 and 14-22 were rejected as failing to particularly point out and distinctly claim the subject matter that Applicant regards as the invention under 35 U.S.C. § 112 second paragraph.

Claims 1-22 were rejected as obvious under 35 U.S.C. § 103(a) over Krebs (U.S. Pat. No. 6,002,642).

Formalities

The title has been revised, new headings provided, and explicit reference made to the priority documents, as required by the Examiner.

The Claimed Invention

The invention pertains to methods and apparatus useful for processing seismic data. As noted in the Background section, it is not possible to match the arrival times of events in raw horizontal data traces with arrival times of events in raw vertical data traces using a constant scaling factor:

> [0011] Methods have been proposed for identifying corresponding PP and PS events in stacked seismic data. In general, these methods assume that there is a constant linear relation between the arrival time of a PP event and the arrival time of the corresponding PS event. The arrival time of an event in the PP data can be mapped onto the expected arrival time of the corresponding event in the PS data by multiplying the PP arrival time by a constant factor, **known generally as "vertical gamma"**. The "vertical gamma" factor is essentially a squeeze/stretch factor, that stretches or squeezes the vertical axis (time axis) of traces for a vertical component of the seismic data to have the same scale as the vertical axis (time axis) of traces of a horizontal component of the seismic data.
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> [0012] The magnitude of the "vertical gamma" factor may be determined simply by manual identification of pairs of corresponding PP and PS events in the stacked seismic data, and deriving the vertical gamma factor from their respective arrival times. It is also known to use an interactive approach in which

> an initial value of the vertical gamma factor is picked from the stacked traces for the horizontal and vertical components, and is then used to assist in identification of further pairs of corresponding PP and PS events. **Once further pairs of corresponding events have been identified, their arrival times may be used to refine the value of the vertical gamma factor.**
>
> **[0013] These prior art techniques may not, however, be applied to raw data traces of the type shown in FIG. 2. The source-receiver offset varies from one raw trace to another, so that the arrival time of an event depends on the offset as well as on the velocity of propagation of acoustic energy. It is therefore not possible to match the arrival times of events in raw horizontal data traces with arrival times of events in raw vertical data traces using a constant scaling factor.** (Emphasis supplied)

One representative method of the invention is reflected in independent claim 1 (as amended), which reads as follows:

> A method of processing raw seismic data traces obtained during a seismic survey to match a seismic event in a first set of raw seismic data traces with a seismic event in a second set of raw seismic data traces, the method comprising: a) identifying a value of a first parameter associated with a seismic event in a first set of raw seismic data traces; b) obtaining, using at least one look-up table, a value of a second parameter, the second parameter being associated with a corresponding seismic event in a second set of raw seismic data traces; and, c) using the values of the first and second parameters to match the seismic event in the first set of raw seismic data traces with the seismic event in the second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures.

Some methods of the invention comprise obtaining the value of the second parameter using a first look-up table of the first parameter against at least one survey parameter and a second look-up table of the second parameter against the at least one survey parameter (claim 2). Other methods of the invention comprise (claim 3) obtaining, using the first look-up table, the value of the survey parameter, or a respective value of each survey parameter, corresponding to the value of the first parameter associated with the event in the first set of seismic data; and obtaining, using the second look-up table, the value of the second parameter corresponding to the value of the survey parameter, or the respective values of each survey parameter. Yet other methods comprise (claim 4) defining a third look-up table of a third parameter against the at least one survey

parameter, and these methods may comprise (claim 5) using the third look-up table, the value of the third parameter corresponding to the value of the survey parameter, or the respective values of each survey parameter. Other methods of the invention (claim 6) are those wherein the at least one survey parameter comprises offset and interface index. Yet other methods of the invention are those wherein (claim 7) the first parameter is PP travel time, and those wherein the second parameter is PS travel time (claim 8). Yet other methods of the invention are those wherein the first parameter is PP travel time and the third parameter comprises reflection depth (claim 9). In some methods of the invention, such as those recited in claim 10, the first parameter of the seismic data is reflection depth. Other methods of the invention comprise displaying the obtained value of the second parameter (claim 11), methods comprising displaying the obtained value of the third parameter (claim 12), and methods wherein the displaying step comprises highlighting a portion of a displayed seismic trace (claim 13). Yet other methods of the invention are those comprising modifying the at least one look-up table on the basis of the obtained value of the second parameter (claim 14), and methods comprising modifying the at least one look-up table on the basis of the obtained value of the third parameter (claim 15). Still other methods of the invention are those wherein the step of modifying the at least one look-up table comprises modifying a model for the velocity of propagation of acoustic energy within the earth. Yet other methods of the invention (claim 21) include those wherein steps (a) and (b) are part of a program fixed in a storage medium, the program being executable by a programmable data processor, and methods wherein steps (a) and (b) are part of a program for controlling a computer.

Another method of the invention comprises (independent claim 17, as amended):

> A method of processing raw seismic data traces obtained during a seismic survey to match a seismic event in a first set of raw seismic data traces with a seismic event in a second set of raw seismic data traces comprising: determining a first look-up table of a first parameter of raw seismic data traces against at least one survey parameter; determining a second look-up table of a second parameter of raw seismic data traces against the at least one survey parameter; using a predetermined model for velocity of propagation of seismic energy within the earth in the determination of the first and second look-up tables; and using the raw seismic data traces and the determined first and second look-up tables to match the seismic event in the first set of raw seismic data traces with the

seismic event in the second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures.

Apparatus of the invention are represented by independent claim 18:

> An apparatus for processing raw seismic data traces obtained during a seismic survey, comprising: means for identifying a value of a first parameter associated with a first event in a set of raw seismic data traces; means for obtaining, using first and second look-up tables, a value of a second parameter, the second parameter being associated with a second event in the set of raw seismic data traces; and means for matching the first event with the second event in the set of raw seismic data traces.

Apparatus within the invention include those comprising a programmable data processor (claim 19), and those wherein the first parameter-identifying means and the second parameter-identifying means are part of a program fixed in a storage medium the program being executable by the data processor (claim 20).

Traversal of Rejections Under 35 U.S.C. § 101

The discussion of the scope and content of the prior art (below) is incorporated by reference into the traversal of the rejection of claims 1-10 and 14-22 under 35 U.S.C. § 101. The Examiner maintains that:

> These claims fail to meet the minimal requirement of a useful, concrete and tangible result of a real physical world interactive end result supported by any algorithm steps, or structure supporting such calculated step with an end result, where the end result limitation/data supports the invention being used in a practical useful, concrete and tangible real world combination manner. That "end result" being the implementation of the inventive gist which is normally the last step of the inventive

> algorithm, or here claimed being the use of the first and second parameter value data and their external useful concrete and tangible relationship(s). As the above updated Guidelines now state, structure (e.g. input devices, sensors, databases, etc.) of any type that supply data for calculations (done by human and/or computer) do not make the claimed invention fall within statutory subject matter until there occurs explicitly a claiming of and meeting the actualization in the real world of a useful, concrete and tangible result.
>
> Note that algorithmic based inventions, especially mathematical or abstract ideas based, where performed using a computer, such computerization still may not make an overall computerized system fall into permitted patentable statutory subject matter. The instant claims fail to explicitly and clearly set forth any end result physical world transformation of any data calculations so as to relate to the real world as/for a tangible practical use. The step(s) may still be at best just internal computer calculations absent any tangible real world relationship. External supply to other structural systems, to a user via display or printing, or some other practical tangible result with the clear useful purpose of such "output", must somehow be minimally claimed for establishing statutory subject matter.

Applicants deem this basis of rejection is respectfully traversed. Applicants have amended independent claims to recite "real physical world interactive end results....the end result supporting the invention being used in a practical useful, concrete and tangible real world combination manner", to the extent that an "end result" is necessary to be recited. Independent method claim 1 has been amended to recite "using the values of the first and second parameters to match the seismic event in the first set of raw seismic data traces with the seismic event in the second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures." Independent method claim 17 has been amended to recite "using the raw seismic data traces and the determined first and second look-up tables to match the seismic event in the first set of raw seismic data traces with the seismic event in the second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures." Independent apparatus

claim 18 has been amended to recite "means for matching the first event with the second event in the set of raw seismic data traces."

Regarding the Examiner's comment that the claims fail to explicitly and clearly set forth an end result physical world transformation of any data calculations", Applicants admit that mathematical calculations are used, and that there is no physical transformation of an article or physical object to a different state or thing recited in the claims. However, this does not determine whether the claims recite patentable subject matter. The Interim Guidelines, hereinafter "Guidelines," intended to assist examiners in determining whether a claim is directed to statutory subject matter under 35 U.S.C. § 101, posted on the USPTO web site on October 26, 2005, and published in the Official Gazette on November 22, 2005, state that "If no physical transformation appears in the claim, check for a "useful, concrete and tangible result."

Thus the Examiner's statement is interpreted by Applicants to mean that the Examiner does not consider the claims to positively recite a useful, concrete, and tangible result; however, as noted above, the independent claims have been amended to provide a useful, concrete, and tangible result, thus this basis of rejection is respectfully traversed.

In analyzing whether a useful, concrete, tangible result is claimed, the focus is on the "result" of the process or method claimed "as a whole", not on the individual steps.[1]

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[1] **Useful, Concrete, Tangible**

If no physical transformation appears in the claim, check for a "useful, concrete and tangible result". **The focus is on the result, not the steps or structure used to produce the result.** A useful, concrete and tangible result must be either specifically recited in the claim or flow inherently therefrom. If no physical transformation appears in the claim then the next step in the analysis is to determine if the claim is otherwise directed to a useful, concrete and tangible result. **The focus is on the result of the claim as a whole, not the individual steps or structure used to produce the result.** A useful, concrete and tangible result must be either specifically recited in the claim or flow inherently therefrom. To flow inherently therefrom, it must occur. If there is a reasonable exception or it is merely likely that it would occur, it does not "flow inherently therefrom" and the claim would need to be amended to specifically recite the result. Even if a judicial exception is a limitation of the claimed invention, e.g. a law of nature, if it is applied to produce a useful, concrete and tangible result, a practical application is provided.

Inclusion of a judicial exception as a limitation of a claimed invention does not preclude the claim from being statutory where the claim as a whole is directed to a practical application because a useful, concrete and tangible result has taken place. However, the claim still needs to be checked to determine if it meets the utility requirement under 35 USC 101.

"Useful"

The claimed invention as a whole must satisfy the utility requirement of 101: specific, substantial, and credible utility. These criteria require evaluation of the specification and the knowledge in the art. When no physical transformation is found, the first factor of the second test for practical application is a determination of whether the claimed invention produces a useful result. For an invention to be "useful" it must satisfy the utility requirement of section 101. The USPTO's official interpretation of the utility requirement provides that the utility of a claimed invention has to be (i) specific, (ii) substantial and (iii) credible.

"Concrete"

Usually, a claimed invention is not concrete when a result cannot be assured or is not reproducible. Concrete is not a requirement that the result must be 100% accurate (e.g., a claim directed to estimating, predicting or approximating something does not necessarily lack concreteness). May require a determination of the level of ordinary skill in the art.

The result of a process or method is typically not considered a part of a method or process claim, because the result itself is not a step. In the present application, concrete and tangible useful results of the inventive methods of claims 1-16, 21, and 22 are clearly stated, for example, in paragraphs 40-46 of the specification discussing Figure 3:

> [0040] In the method illustrated in FIG. 3, an event in one of the data sets is initially selected. This is represented by step 1 in FIG. 3. In FIG. 3, the selected event is in the raw PP data set, being an event in one of the PP raw data traces of panel D, but the trace that is selected initially could equally well be in one of the PS raw data traces.
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> [0041] Selecting an event in a particular data set, by selecting an event in a raw data trace, defines a time, corresponding to the arrival time of the event. Where the selected event is a PP event, a PP travel time is defined. Selecting an event also defines an offset, corresponding to the source-receiver offset used to acquire the trace in which the selected event occurs. For the particular PP event selected in FIG. 3, the offset is 3003 metres and the PP travel time is 2.131 seconds.
>
> [0042] Since both the PP travel time and the offset are known, the "LUT time PP" look-up table may be used to determine the interface index corresponding to the selected event.
>
> [0043] Next, at step 2, the "LUT time PS" look-up table is used to find the PS travel time corresponding to the offset (as determined for the original selected event) and the interface (as determined from the "LUT time PP" look-up table). This produces the PS travel time of the PS event that corresponds to the PP event selected at step 1. **In FIG. 3, the PS travel time corresponding to the selected PP event is determined to be 3.611 seconds.**
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> [0044] Once the PS travel time corresponding to the selected PP event has been determined, it is straightforward to identify, in the raw PS data set, the PS event corresponding to the selected PP event. The corresponding PS event is the event in the raw PS data that occurs in the raw PS data trace having the same offset as the selected PP event and that occurs at the PS travel time determined in step 2. This is indicated as step 3 in FIG. 3.

"Tangible"

"Real world" result. Not necessarily tied to a machine; not a duplicate of "physical transformation". In other words, the opposite of "tangible" is "abstract". Thoughts are not "real world" results. Example: Calculating a price of an item to sell and then conveying the calculated price to a potential customer.

> [0045] **The present invention thus allows corresponding PP and PS events to be determined in raw data traces.**
>
> [0046] The depth of the reflection point that gives rise to the event selected at step 1 may also be determined, using the "LUT depth" look-up table. **In FIG. 3, the reflection depth corresponding to the selected PP event is determined to be 2073.291 metres.** (Emphasis added)

Furthermore, concrete and tangible useful results of the inventive method of claim 17 are clearly stated, for example, in paragraphs 76-77 of the specification:

> [0076] The invention, as described above, provides, starting from an initial velocity model, a method of navigating from an event in a data trace relating to one component of seismic data to a corresponding event in a data trace relating to another component of the seismic data. **The invention may be used to provide a quality control (QC) measure.** If there is a discrepancy between, for example, the estimated PS travel time for an event corresponding to a PP event and the actual position of the corresponding PS event, this suggests that the velocity model is incorrect. **The invention may therefore be used to provide QC on the velocity model. For QC purposes, it is sufficient to display the results.** For example the offset and PS travel time calculated to correspond to a selected event in the raw PP data set may be displayed on a display screen (for example the display screen of a computer) or as hard copy, as shown in the right hand lower corner of FIG. 3. **An operator can determine whether the raw PS data set contains an event at that time and offset.**
>
> [0077] **In addition to QC purposes, the invention may also be used to refine one or more of the look-up tables by refining the velocity model used to determine the look-up tables.** If the results show a discrepancy between the estimated position of an event and the actual position of an event it is possible to use this result to up-date the velocity model used to determine the look-up tables, and re-calculate one or more of the look-up tables using the up-dated velocity model. **The present invention thus makes possible dynamic, interactive correction of a velocity model.** The correction may be performed in an iterative manner, until the estimated position of an event and the actual position of that event are substantially the same. The correction of the velocity model may be performed as a continuous process while the user is selecting events, and the look-up tables can be recalculated "on-the-fly". (Emphasis supplied)

For an invention to be "useful" it must satisfy the utility requirement of section 101. The USPTO's official interpretation of the utility requirement provides that the utility of a claimed invention has to be (i) specific, (ii) substantial and (iii) credible. (Guidelines). Applicants submit that, based on the discussion of results above, the recited

methods have specific, substantial, and credible utility. Indeed, Applicants' assignee and its competitors base much of their business on these specific, substantial and credible utilities, typically supplying seismic data to hydrocarbon exploration and production customers.

Applicants submit that one of ordinary skill in the seismic data acquisition art would recognize that the inventions recited in all of claims 1-22 recite concrete results. The Guidelines themselves note that "a claim directed to estimating, predicting or approximating something does not necessarily lack concreteness." The reference cited against the present application, Krebs, also is evidence of the concreteness of the inventions recited in the claims.

Applicants submit the inventions recited in the claims recite tangible results. The results are not abstract, but allow potential or actual customers to plan and conduct hydrocarbon exploration and production operations.

<u>Rejections Under 35 U.S.C. § 112 paragraphs 2 and 4</u>

Claims 1-12 and 14-22 were rejected as failing to particularly point out and distinctly claim the subject matter that Applicant regards as the invention under 35 U.S.C. § 112 second paragraph. Specifically, the Examiner maintains that:

The bodies of the independent claims, as well as the dependent claims not rejected under 35 U.S.C. 101 above, appear to never completely recite the complete invention and its statutory gist of the algorithmic relationships where the final step is utilized for some purpose such as displaying of some result. According to the updated Guidelines, the ultimate result of an algorithmic based invention must be found explicitly recited and claimed in a useful, concrete and tangible real world interactive result. See the above 101 rejection remarks. The claims are therefore deemed incomplete and failing to completely recited the required minimum invention that would constitute a statutory subject matter basis.

Claims 1-12 and 14-22 are also deemed indefinite and incompletely reciting the invention as to where and what constitutes the inventive gist of "processing seismic data" as the independent claims' preambles so state the invention is directed. The bodies of these and dependent claims appear to never clearly state where any modification or processing occurs of the initial existing various seismic data. At best there is processing of data associated with this initial set(s) of seismic data, not the seismic data itself. Claim 13 is the only claim that clearly and explicitly does anything to any seismic data to be considered to meet "processing seismic data". Dependent claims of the above do not resolve their problems, and likewise fall for the same reasons.

The Examiner has apparently misinterpreted the Guidelines, and this may have lead to an erroneous rejection under §112 paragraphs two and four. The Guidelines clearly state that the claims *ARE NOT* required to recite a useful, concrete and tangible result: "A useful, concrete and tangible result must be *either* specifically recited in the claim *or* flow inherently therefrom. To flow inherently therefrom, it must occur. If there is a reasonable exception or it is merely likely that it would occur, it does not "flow inherently therefrom" and the claim would need to be amended to specifically recite the

result." (Emphasis supplied). Despite this, Applicants have amended the independent claims as detailed herein, and respectfully maintain that useful, concrete, and tangible results are explicitly recited, and therefore the claims are not "incomplete" and do not fail to completely recite "the required minimum invention."

The other concern raised by the Examiner, that claim 1-12 and 14-22 are indefinite and failed to completely recite where and what constitutes "processing of seismic data", Applicants respectfully maintain that the various amendments to the independent claims have rendered this rejection moot or traversed.

<u>Rejections Under 35 U.S.C. § 103(a)</u>

A. <u>The Scope and Content of the Prior Art</u>

1. Krebs (U.S. Pat. No. 6,002,642)

This reference, cited by the Examiner, discloses (see the abstract) a method of migrating seismic data using offset checkshot survey measurements. The offset checkshot survey measurements involve raypaths similar to the migration raypaths for the seismic data, and are used to determine direct arrival traveltimes to receivers in a borehole. Embodiments provide for direct use of the traveltimes in migration, or indirect use of the traveltimes in migration via construction of a migration velocity model. The velocity model embodiments further provide for either traveltime error correction via use of interpolated error functions or construction of migration error tables. The invention can be employed for time, depth or Kirchhoff migration, in either two or three dimension, and in either prestack or poststack applications. The invention may be used to migrate any type of seismic data, including compressional-wave, shear-wave, and converted-wave seismic data. Importantly, Krebs discloses that (see his Background section):

> Seismic data migration typically uses diffraction traveltimes from subsurface imaging points to the source and receiver locations to produce an image of the subsurface reflectors. The diffraction traveltimes are the seismic signal propagation times along raypaths from each imaging point to the source and receiver locations. **The propagation times, which are usually plotted as diffraction traveltime curves, are used after appropriate preprocessing *of the raw seismic data* to generate an estimate of the correct location of the reflector. The migration process will be familiar to those versed in the art.**

> Incorrect diffraction traveltime curves lead to **at least two undesirable migration consequences**. First, the image of the reflector which results will be **poorly focused**, making interpretation difficult. Second, the reflector may be **mispositioned**, a serious drawback in oil and gas exploration where accurate mapping of the subsurface structure is important.
>
> None of the above methods for determination of migration velocities account for velocity anisotropy (the variation of velocity with respect to the propagation angle of a raypath). Anisotropy is frequently present in seismic data as a higher order term in the diffraction event time-offset curves. Although a reasonably good match to observed seismic data can usually be obtained from an isotropic migration velocity model, for example the migrated images may be reasonably well-focused and consistent, **the reflectors may nevertheless be mispositioned. Typically, any such mispositioning results from the fact that reflections from steep features have raypaths involving a large range of propagation angles, each of which may have velocities not taken into account by the isotropic model. In such cases additional information must be used to determine an anisotropic velocity model.** This is generally a difficult task, given that even in laterally homogeneous media the higher order term may be hard to separate from terms associated with vertical inhomogeneities.
>
> Once a diffraction traveltime curve has been derived and the seismic data has been migrated, it is useful for the data analyst to have an estimate of the accuracy of the position of the reflector in the migrated image. Conventionally, that estimate is obtained by **correlating borehole measurements, such as from sonic logs or dipmeters, with the image. High correlations indicate an accurate migration.**
>
> **There are several limitations to the correlation approach however.** A poor correlation with borehole data may indicate migration error, but does not quantify that error. In addition, other problems, such as inaccurate estimation of the seismic wavelet, can lead to poor correlation between well data and a seismic image. And finally, a good correlation between well data and the shallow dipping reflectors in the image does not necessarily imply that the steep dips are accurately migrated. **In particular, because wells do not always penetrate steeply dipping reflectors, such as the flanks of salt domes, the correlations are not meaningful at the locations in which the greatest accuracy is desired. Because hydrocarbon reserve estimates can be quite sensitive to the position of the steeply dipping reflectors, the correlations are often of limited value to the analyst.** (Emphasis supplied)

2. Muijs, et al. (U.S. Pat. No. 6,834,235)

This reference is the U.S. Patent version of corresponding PCT application WO02/46792 cited in the IDS, and which Applicants respectfully request be made of

record. The WO02/46792 application was cited in the PCT International Search Report as a "novelty destroying" reference for original claims 1, 7-12, and 18-22.

Muijs, et al. address the problem that not all downwardly-propagating seismic energy that is incident on the sea-bed will pass into the earth's interior, and a proportion will be reflected upwards back into the sea. Furthermore, the source may emit some upwardly-propagating seismic energy which will reach the receiver after undergoing reflection at the sea-surface. These effects give rise to seismic energy paths that involve more than pass through the water. These paths are known as "water layer multiple" paths. As explained in this reference, the existence of many paths from the source to the receiver in seismic surveying complicates analysis of seismic data acquired by the receiver. When seismic data acquired by the receiver are analyzed, it is necessary to distinguish events arising from a primary reflection, events arising from the direct wave and events arising from a water-layer multiple. In deep water there is generally a significant time delay between an event arising from the direct wave and an event arising from a water-layer multiple, but in shallow water an event arising from a water-layer multiple may occur very shortly after an event arising from the direct wave. A further factor that complicates the analysis of seismic data acquired by the receiver is that the properties of the earth are not uniform. In particular, there is frequently a layer at or near the surface whose properties may well be significantly different from the properties of the underlying geological structure (the "basement").

Muijs, et al. discloses a method of processing multi-component seismic data acquired at a receiver comprising determining a suitable decomposition scheme to use. This makes use of the existence of pairs of wavefield components that are uncoupled from one another. If there is no physical coupling between first and second wavefield components, the first and second components should not arrive at a receiver location at the same time. The method comprises decomposing a first portion, for example a test portion, of the seismic data into a plurality of wavefield components using an initial decomposition scheme. First and second wavefield components of the decomposed data that should be uncoupled from one another are then selected, and their product is determined. Since the first and second wavefield components of the decomposed data

should be uncoupled from one another, their product should be zero or close to zero and a product that is significantly different from zero indicates that the decomposition scheme is inaccurate.

3. Robertsson, et al. (published U.S. Application 20040076077)

This reference is the U.S. published patent application version of corresponding PCT application WO02/059647 cited in the IDS, and which Applicants respectfully request be made of record. The WO02/059647 application was also cited in the PCT International Search Report as a "novelty destroying" reference for original claims 1, 7-12, and 18-22.

Robertsson, et al. address the problem in processing marine seismic data that frequently there is a layer at or near the surface whose properties may well be significantly different from the properties of the underlying geological structure or "basement", as mentioned in Muijs, et al. This can occur if, for example, there is a layer at or near the earth's surface that is less consolidated than the basement. In particular, the velocity of seismic energy may be significantly lower in the surface or near-surface layer than in the basement, and such a surface or near-surface layer is thus generally known as a "low-velocity layer" (or LVL). As Robertsson, et al. explain, this difference in velocity will produce a shift in the travel time of seismic energy compared to the travel time that would be recorded if the surface or near-surface layer and the basement had identical seismic properties, and these shifts in travel time are generally known as "static shifts", or just "statics". The static shift generated by a surface or near-surface low-velocity layer depends on the thickness of the layer, and on the velocity of propagation of seismic energy through the layer. Lateral variations usually occur in both the thickness of a low-velocity layer and the propagation velocity through the layer, so that the static shift observed at a seismic receiver at one location is likely to be different from the static shift observed at a receiver at another location.

Robertsson, et al. discloses (see the abstract) a method of determining seismic properties of a layer of the seabed, in particular a surface or near-surface layer, comprising directing seismic energy propagating in a first mode at a boundary face of the layer so as to cause partial mode conversion of the seismic energy at the boundary face.

For example partial mode conversion may occur when seismic energy propagates upwards through the interface between a surface or near-surface layer and the basement, owing to the difference in seismic properties between the surface or near-surface layer and the basement. In the invention, the two modes of seismic energy--that is the initial mode and the mode generated by mode conversions at the interface--are received at a receiver. The difference in travel time of the two modes between the interface and the receiver is determined from the seismic data acquired by the receiver.

B. <u>Differences between the Cited Art and the Claimed Invention</u>

Krebs does not teach or suggest processing of raw seismic data. In fact, Krebs notes specifically that "the propagation times, which are usually plotted as diffraction traveltime curves, are used *after appropriate preprocessing of the raw seismic data* to generate an estimate of the correct location of the reflector. . . .Incorrect diffraction traveltime curves lead to at least two undesirable migration consequences." These consequences are *"poorly focused" reflector images*, making interpretation difficult, and *mispositioning of the reflector*, "a serious drawback in oil and gas exploration where accurate mapping of the subsurface structure is important." Therefore, one of ordinary skill in the art at the time the invention was made would not have been lead to processing raw seismic data.

Further, Krebs teaches away from any process using matching or correlating data. In discussing correlation techniques in the Background, Krebs states that "there are several limitations to the correlation approach however. A poor correlation with borehole data may indicate migration error, but does not quantify that error. In addition, other problems, such as inaccurate estimation of the seismic wavelet, can lead to poor correlation between well data and a seismic image. And finally, a good correlation between well data and the shallow dipping reflectors in the image does not necessarily imply that the steep dips are accurately migrated. In particular, because wells do not always penetrate steeply dipping reflectors, such as the flanks of salt domes, the correlations are not meaningful at the locations in which the greatest accuracy is desired.

Because hydrocarbon reserve estimates can be quite sensitive to the position of the steeply dipping reflectors, *the correlations are often of limited value to the analyst.*"

Muijs, et al. and Robertsson, et al. also fail to disclosure or suggest the claimed inventions. Regarding Muijs, et al., the techniques described therein, while valid and useful, are distinct from the methods and apparatus herein. Muijs, et al. disclose using pairs of wavefield components that are *uncoupled* from one another. If there is no physical coupling between first and second wavefield components, the first and second components should not arrive at a receiver location at the same time. Muijs, et al., would have taught one of ordinary skill in the art to select first and second wavefield components that should not have arrived simultaneously at the receiver, and multiply the first wavefield component by the second wavefield component. (See claim 1) On the other hand, Applicants' method recited in claim 1 seeks to use the values of first and second parameters to *match* a seismic event in a first set of raw seismic data traces with a seismic event in a second set of raw seismic data traces, and thus provide knowledge of one or more subterranean geological structures.

Regarding Robertsson, et al., although the techniques disclosed therein are useful, Robertsson, et al. would have taught one of ordinary skill to direct seismic energy propagating in a first mode at a boundary face of two layers of differing properties so as to cause partial mode conversion of the seismic energy at the boundary face. The two modes of seismic energy--that is the initial mode and the mode generated by mode conversions at the interface--are received at a receiver. The difference in travel time of the two modes between the interface and the receiver is determined from the seismic data acquired by the receiver. It may be seen that the problem addressed by Robertsson, et al. is quite different from the problem addressed herein of processing raw seismic data and matching one event in a first set of raw seismic data with a second event in a second set of raw seismic data.

C. Traversal of Rejections Under 35 U.S.C. § 103(a)

Given the scope and content of the prior art and the differences between the art and the claimed invention, Applicant respectfully maintains that all claim rejections under 35 U.S.C. § 103(a) are respectfully traversed.

Applicants respectfully maintain the Examiner has failed to make out a *prima facia* case of obviousness for the amended versions of claims 1-22. To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in thé knowledge generally available to one of ordinary skill in the art, to modify a single reference, or to combine reference teachings. Second, there must be a reasonable expectation of success of the modified single reference or combined reference teachings. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on Applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). As stated *In re Gordon* 221 USPQ 1125-1127 (Fed. Cir. 1984) and reaffirmed in *In re Mills*, 16 USPQ 2d 1430, 1432 (Fed. Cir. 1990):

> The mere fact that the prior art could be so modified would not have made the modification obvious unless the prior art suggested the desirability of the modification.

Utilizing these principals in the present situation, it can be seen that there is totally lacking in Krebs, Muijs, et al., and Robertsson, et al.:

1) any suggestion or hint of the desirability of a modification which would entail using the values of first and second parameters to match a seismic event in a first set of raw seismic data traces with a seismic event in a second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures;

2) any expectation of success that using the values of first and second parameters to match a seismic event in a first set of raw seismic data traces with a seismic event in a second set of raw seismic data traces would improve seismic survey data; and

3) no teaching or suggestion of *all* the claim limitations of pending independent Claims 1, 17, and 18.

Accordingly, it is abundantly clear that no *prima facia* case of obviousness can be made and that the methods and systems defined in the pending clams are manifestly nonobvious in view of the prior art of record under 35 U.S.C § 103(a).

Assuming, *arguendo,* that the Examiner has presented a *prima facia* case of obviousness, Applicant offers the following remarks. First of all, it must be reiterated that "obviousness cannot be established by modifying and/or combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the modification or combination. Under section 103(a), teachings of references can be combined [or references modified] *only* if there is some suggestion or incentive to do so." *ACS Hospital Systems, Inc. vs. Montefiore Hospital*, 221 USPQ 929, 933 (Fed. Cir. 1984) (emphasis in the original). Applicant herein submits the prior art of record fails to provide any such suggestion or incentive, either explicitly or implicitly. (It is recognized that the prior art need not have express written motivation to combine. *Ruiz vs. A.B. Chance Co.*, 357 F.3d 1270, 69 USPQ2d 1686 (Fed. Cir. 2004).)

Claims 1-22 were rejected as obvious under 35 U.S.C. § 103(a) over Krebs. These rejections are respectfully traversed. Neither Krebs nor the other references discussed herein teach or suggest using the values of first and second parameters to match a seismic event in a first set of raw seismic data traces with a seismic event in a second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures. Nevertheless, the examiner maintains that it would have been obvious at the time the invention was made to a person having ordinary skill in the art to which such subject matter pertains to modify Krebs to render claims 1-22 obvious.

The Examiner states that "while the Krebs reference does not make use of identical language and explicit expression of various signal components, such as "look-up table" or pp type seismic data components, such are nevertheless found "fully and equivalently" taught by the reference in its teachings." The Examiner states, for example, that "the claimed plural look-up tables are met by the teachings of the tables that are used for error correction of the various types of seismic data signal components, and the teaching that the taught techniques may be applied to other types of seismic data, from 2D to 3D datasets."

Regarding the Examiner's comment about the differences in language, and that even though Krebs does not use "identical language and explicit expression", "such are nevertheless found "fully and equivalently taught" by Krebs, Applicants respond by reminding the Examiner that in an obviousness inquiry, it is necessary to

> "evaluate the claimed subject matter as a whole against the teachings of the prior art references of record. 35 U.S.C. 103. References are evaluated by ascertaining the *facts fairly disclosed therein as a whole*. It is impermissible to first ascertain factually what appellants *did* and then view the prior art in such a manner as to select from the random facts of that art only those which may be modified and then utilized to reconstruct appellants' invention from such prior art." (Emphasis in the original).
>
> *In re Shuman and Meinhardt*, 150 USPQ 54, 57 (CCPA 1966)

In this regard, it appears the Examiner is unfairly neglecting those portions of Krebs that teach away from, or teach something different from, the presently claimed invention. Applicants pointed out above that Krebs notes specifically that "the propagation times, which are usually plotted as diffraction traveltime curves, are used *after appropriate preprocessing of the raw seismic data* to generate an estimate of the correct location of the reflector. . . .Incorrect diffraction traveltime curves lead to at least two undesirable migration consequences." These consequences are *"poorly focused" reflector images*, making interpretation difficult, and *mispositioning of the reflector*, "a serious drawback in oil and gas exploration where accurate mapping of the subsurface structure is important." Therefore, one of ordinary skill in the art at the time the invention was made would not have been lead to processing raw seismic data. Further, Krebs teaches away from any process using matching or correlating data. In discussing correlation techniques in the Background, Krebs states that "there are several limitations to the correlation approach", which are discussed hereinabove.

Furthermore, Applicants respectfully maintain that, whether or not look-up tables were known, and whether or not the techniques of Krebs may be applied to other types of seismic data, this still does not teach or suggest using the values of first and second parameters to match a seismic event in a first set of raw seismic data traces with a seismic

event in a second set of raw seismic data traces and thus provide knowledge of one or more subterranean geological structures.

Regarding the highlighting feature of claim 13 ("A method as claimed in claim 11 wherein the displaying step comprises highlighting a portion of a displayed seismic trace."), the Examiner maintains that this feature is disclosed by Krebs in displaying a portion of his data, and that this "highlights" that portion of the data. The Examiner states that "if "highlighting" means anything than its *broadest possible interpretation* as permitted in ordinary language, then such should be explicitly claimed and shown supported in applicants' original disclosure as filed – however, such techniques of using color or shading for geologic or data features emphasis were notoriously well known for such further purposes." The Examiner is apparently referencing MPEP section 2111, which requires interpreting claim limitations *as broadly as reasonably possible*, and for this he is to be commended for following the guidance of *In re Hyatt*, 211 F.3d 1367, 1372, 54 USPQ2d 1664, 1667 (Fed. Cir. 2000) ("During patent examination, the pending claims must be "given their broadest reasonable interpretation consistent with the specification.") However, with all due respect, the Examiner has apparently misunderstood and misapplied MPEP 2111. There is a difference between "broadest *possible* interpretation" as the Examiner states, and "broadest *reasonable* interpretation", as stated in *In re Hyatt* and in MPEP 2111. Applicants view the Examiner's interpretation of "highlighting" as displaying any portion of data as unreasonable. Furthermore, it appears the Examiner has focused on the Krebs reference instead of the present application claims and specification. In other words, it appears the Examiner is interpreting *the reference* as broadly as possible, rather than interpreting the present *claims consistent with the present specification* as required by *In re Hyatt*. Applicants submit that the claims' scope is consistent with the specification. In the specification at the following paragraphs, Applicants discuss highlighting certain seismic data on a computer screen:

> [0047] In a preferred embodiment, the traces are displayed as shown in FIG. 3 on a computer screen. The event selected at step 1 is selected by, for example, positioning the cursor of a computer mouse over the selected event and "clicking" the mouse button. When the corresponding PS travel time has been

determined, the event that occurs at that travel time in the raw PS data trace having the same offset at the selected event may be automatically *highlighted* on the computer screen in some way. *This may be done, for example, by changing the background colour of a small region of the screen surrounding the corresponding PS event.*

[0048] Additionally or alternatively, it is possible to identify an event in the offset-corrected PP and/or PS data sets that has the same offset as the originally selected event and that has the depth determined from the "LUT depth" look-up table. This is indicated in FIG. 3, as step 4. The event identified in the offset-corrected PP and/or PS data sets may again be *highlighted* on the computer display in any convenient manner.

[0053] The values determined for tps and d may be displayed to the user, as shown in the bottom right of FIG. 3. Additionally or alternatively, the display may *highlight* the corresponding point at (o, tps) in the raw PS seismic data set of panel E and/or the corresponding points at (o, d) in the offset-corrected and time-to-depth corrected PP and PS seismic data sets of panels F and G.

[0082] The incidence angle for the propagating wave at any interface for an offset can always be estimated as well. If the map functions are generated by ray-tracing, an exact estimate of the incidence angle is always calculated, and this could be recorded for later use in separate look-up tables. This angle information can be used to sort the PP and PS seismic gathers into angle bands, or the incidence-angles as a function of depth and offset could be plotted as contour lines on top of the PP and PS seismic gathers in real time. Optionally, the user will then be able to link the horizontal movement of the cursor and scroll bar to the incidence angle field, enabling a horizontal cursor tracking based on incidence angle instead of offset. For example if the user locates the cursor on a sample at interface index 5 and offset=x_{pp}, in the PP seismic gather, it is possible to look up the incidence angle α_{pp} for the propagating wave at that location. The corresponding offset x_{ps} in the PS gather which has the same incidence angle for the given interface can then be determined, and that location in the PS gather can be *highlighted*.

(Emphasis supplied)

The Examiner concludes by stating that "since the variations in claim language do not involve the concept of the invention, as exemplified above, and the reference covered such variations as its disclosure was adequate enough teaching to one of ordinary skill in the art at the time of filing of applicants' application to make, use and cover the claimed invention, such claimed invention would therefore have been obvious and does not involve any inventive concept or novelty." It is clear, however, from a fair reading of Krebs referred to above, that the Examiner has misinterpreted the claimed invention, and unfairly read Krebs as disclosing or suggesting features recited in the present claims while

disregarding portions of Krebs that teach away from the present invention, and this has lead to an erroneous obviousness rejection. "The relevant portions of a reference include not only those teachings which would suggest particular aspects of an invention to one having ordinary skill in the art, but also those teachings which would lead such a person away from the claimed invention." *In re Mercier*, 185 USPQ 774, 778, CCPA 1975:

> The board's approach amounts, in substance, to nothing more than a hindsight "reconstruction" of the claimed invention by relying on isolated teachings of the prior art without considering the over-all context within which those teachings are presented. Without the benefit of appellant's disclosure, a person having ordinary skill in the art would not know what portions of the disclosure of the reference to consider and what portions to disregard as irrelevant, or misleading. Id. at 1975. In view of Krebs as a whole it would not have been clear to one of ordinary skill in the seismic art how to modify Krebs as suggested by the examiner to arrive at the claimed invention.

Conclusion

Given the proposed claim amendments and comments submitted herein, it is now respectfully submitted that all pending claims, as amended, would be in condition for allowance if the amendments are entered. However, should the Examiner have further objections, rejections, or comments to bring the case to conclusion, the Examiner is cordially requested to contact the undersigned prior to further rejection.

Respectfully submitted,

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January 15, 2007

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